10/566315
IAP5 Rec'd PCT/PTO 27 JAN 2006

SYSTEM FOR REPRODUCTION OF VARIABLE IMAGES WITH ANGLE OF VIEW

The present invention concerns the reproduction of images, and in particular systems allowing the reproduction of an image with a perception of depth.

Known systems allowing the display of at least two images on the same screen are principally utilized to create a perception of depth. The perception of depth is due to two effects: on the one hand, to the difference between the images viewed by the two eyes, on the other, to the modification of these images when the observer moves. Besides the change of perspective, the elements situated in the foreground and the background present variable relative positions according to the position of observation.

A first existing reproduction system allows the display of multiple images simultaneously on the same screen 1, and is illustrated in figures 1 and 2. This system comprises multiple source images, most often 4, with each image being constituted by a multitude of luminous pixels. The pixels from different sources are interlaced: the pixels from a single source are identified by a single reference number between 1 and 4 in the sequences from the left part of the figure. This system also comprises cylindrical lenses positioned vertically. These lenses form a lenticular network 2 applied to screen 1. A group of horizontally interlaced images is formed on the screen. The lenticular network sends out each of these images in a sector of a different direction.

The perception of depth comes from sending a different image towards the right eye and the left eye of the observer, it is necessary for the width of the sector where the image is visible to be of the order of size of the spacing of the eyes of the observer situated at the average distance of observation. Both eyes of an observer (the observers are identified by the printed characters, and their eyes by crosses; the dash-dot lines correspond to the axes of the point of view on the image) therefore look at two different images, which brings about a perception of depth (in the case of observer A). A slight movement of the observer also implies that the image view is changed. Due to the spatial periodicity of the groups of 4 pixels and of that of the lenses, the sequence of 4 images repeats itself identically in the neighboring sectors, as illustrated in Figure 2.

This system presents some drawbacks. This system utilizes a complex control of different point sources and a complex and expensive lenticular network in order to generate each image in a sector of the visualization environment. This system requires in particular an extremely precise alignment between the screen and the optical system. In addition, the geometric differences tolerated between the observation sectors need to be very limited, which involves a very high manufacturing cost, and limits the angular area of observation of the different images. The utilization of sets of images placed side by side reverses or deforms the relief (pseudoscopy) when an observer turns one eye to one set and the other eye to another set (in the case of observer B).

A second solution consists of using active eyewear, where the transparence or the opacity is synchronized with the image on the screen. The displayed image includes alternately an image intended for the right eye then an image intended for the left eye. The lenses of the eyewear, using liquid crystals for example, are alternately rendered transparent, in synchronization with the image on the screen that is intended for them.

Such eyewear is heavy and expensive, requires power and cabling for synchronization with the screen.

The invention therefore aims to resolve one or more of these drawbacks. The invention proposes therefore a system for reproduction of images, comprising:

- at least one input for the simultaneous reception of respective image signals, these image signals corresponding to different images and comprising pixel signals,

- a screen presenting a plurality of pixels with variable optical transmissibility

- at least one light source for each image signal, projecting light on the screen, each source being associated with a set of pixels

- a device for channeling the light from each light source exclusively towards the associated set of pixels this device comprising an alignment grid interposed between the sources and the screen, transmitting the light generated by each source exclusively towards its associated set of pixels.

- a sequential lighting command for said light sources

- a device for driving the transmissibility of the screen pixels, applying the pixel signals on the screen in order to multiplex the display of different corresponding images on the screen, synchronizing screen display of one image corresponding to one of the image signals with the lighting of the source associated with this image signal, and driving the pixels for displaying each image in one of said respective set of pixels of the screen

- a Fresnel lens positioned on the light path traversing the screen

- the Fresnel lens, the screen and the light sources being positioned so that the images transmitted are focused towards distinct respective areas of a visualization environment of the screen.

According to another variant, the channeling devices are constituted by light deflectors, such as prisms or mirrors, directing the light leaving a source exclusively towards its associated set of pixels.

According to another variant, the light deflectors are constituted by lenses focusing the light issued from a source exclusively towards its associated set of pixels.

According to yet another variant, the light deflectors are reflectors.

Adjacent light sources can also be provided.

According to a variant, the light sources are slightly spaced and the system includes diffusers positioned on the light path between the sources and the screen.

According to another variant, the system comprises multiple respective image signals generators, signals corresponding to respective images of a single object according to the different points of view, the generators being connected to the signal reception input.

According to another variant, the generators are constituted by a processor generating said image signals from a modeled object.

According to yet another variant, the generators are constituted by a processor generating said image signals by processing of a single image of the object.

The invention also concerns a group of such systems having the same screen in common.

The invention also concerns a method for reproduction of images, comprising the steps consisting of:

- simultaneously receiving multiple image signals corresponding to different images and comprising pixel signals

- sequentially generating a light signal for each image signal by a light source specific to it, these light signals being synchronized with the screen display of an image corresponding to the respective image signals

- projecting the light signals onto a display screen (2), channeling each generated light signal exclusively towards a set of pixels on the screen associated with this signal

- applying the pixel signals on the screen to multiplex the display of different images on the screen by modifying the transmissibility of the screen's pixels; the display of images by the screen being spatially multiplexed

- focusing the displayed images towards the distinct respective areas of the screen's visualization environment.

According to one variant, the received image signals correspond to the respective images of a single object according to different points of view.

Other features and advantages of the present invention will appear more clearly with the reading of the following description, provided as an illustrative and non-limiting example and made in reference to the following figures, within which:

- Figure 1 is a horizontal cross-section view of a portion of a screen with a lenticular network

- Figure 2 is an overhead view of observation sectors of the screen from Figure 1

- Figure 3 is a horizontal cross-section view of a portion of a sample system according to the invention

- Figure 4 is a chronogram of the operation of the system from Figure 3

- Figures 5 through 7 are horizontal cross-section views of other systems according to variants of the invention

The invention proposes a system for reproduction of images, combining: respective image signals applied to a reception input, a screen with pixels with controllable optical transmissibility,

a light source for each image signal and a device for driving the transmissibility of the pixels for multiplexing the display of different corresponding images on the screen, and a Fresnel lens positioned in the path of the light traversing the screen.

The respective layout of the screen, Fresnel lens and light sources is such that the light lens converges light that leaves a source on an area that is associated with it in the visualization zone, so that this convergence is independent of the region where the rays traverse the screen. The nominal plane of observation is that where the Fresnel lens forms the image of the sources.

A first sample system according to the invention is illustrated in Figure 3. The system for reproduction of images according the invention comprises at least one input for the simultaneous reception of respective image signals. These image signals correspond to different respective images. Each image is destined to be viewed in different areas of the visualization environment but must be masked in the other areas of the visualization environment. These image signals comprise the pixel signals.

The system comprises a screen 2 presenting a plurality of pixels with variable optical transmissibility. Screen 2 is intended to display the images in the different areas of the visualization environment 8.

In addition, the system comprises at least light sources in a number at least equal to that of the image signals. The light sources 71 to 77 are illustrated in the form of a group 1 of light sources.

Each light source is intended to project its light on screen 2, which selectively traverses screen 2 to display a desired corresponding image in an area of the visualization environment 8.

The system also comprises a device for driving the transmissibility of the screen pixels. This device applies the pixel signals to modify the optical transmissibility of the desired pixels. By selectively modifying the transmissibility of a set of pixels and in projecting light on these pixels, the driving device forms an image. The driving device applies the pixel signals on the screen so as to multiplex the display of different corresponding images on the screen.

In addition, the system comprises a Fresnel lens 3 positioned on the path of the light traversing the screen. The placement of the Fresnel lens 3, the screen 2 and each light source is such that the associated image displayed by the screen is focused towards a distinct respective area of a visualization environment 8 of the screen. The observation area associated with each source extends around the image from the source formed by the Fresnel lens in a volume that a person skilled in the art would be able to determine as a function of the optical properties of this lens. The Fresnel lens therefore assures the directivity of a given light beam towards a area of the associated visualization environment. As illustrated in Figure 3, the Fresnel lens makes the light coming from a source 76 (considered here as a point) converge on a respective point P in the visualization environment.

As illustrated, this convergence is independent of the point where the rays issued from the source 76 traverse the screen 2.

Compared to the system with the lenticular network from the state of the art, it can be observed that the display of different images by the system can cover an increased angular field of the observation environment, with a simplified control of sources and allowing as well multiplexing the display of an increased number of images.

According to the variant represented in figure 3, the driving device temporally multiplexes the display of the images. The driving device then comprises, for example, a sequential lighting control of the light sources 71 to 77. The driving device thus synchronizes the display of an image corresponding to one of the image signals, with the lighting of the source associated with this image signal.

The synchronization of the sources and of the display of their respective images on screen 2 is illustrated by the chronogram in Figure 4. In the chronogram from Figure 4 the display of 3 images is multiplexed. The system thereby presents 3 light sources, associated with the respective images. The system thereby displays three different images in three different areas of the visualization environment within one cycle. The display frequency of the screen must therefore be n times greater than the frequency of the cycle, where n corresponds to the number of different images whose display must be temporally multiplexed in the visualization environment 8. The synchronization of the sources and screen 2 can be managed by an internal command of the system, by a specific internal clock or by a clock external to the system.

The driving device controls the display of an image so that the associated light source is lit and so that the other light sources are extinguished. Thus, during the display of an image, this image is not visible except in the area of the visualization environment which is assigned to it and not in the others. Screen 2 preferably has a sufficiently reduced persistence time so that the image displayed while one source is lit is totally erased and replaced by a new image during the following time interval corresponding to the lighting of another source. The cycle's repetition frequency is sufficiently high that the extinguishing of a source between two successive cycles cannot be perceived in the visualization environment.

According to another variant illustrated in figures 6 and 7, the system in addition comprises a device for channeling the light from each light source towards a group of pixels on the screen exclusively associated with that source. The driving device drives the pixels to display each image on the screen's respective set of pixels. Thereby a spatial multiplexing for the display of images on the screen is realized. For a given number of different images to display, the spatial multiplexing alone or combined with temporal multiplexing allows the reduction of the display frequency of the screen in comparison to temporal multiplexing alone.

Because a light source only illuminates an exclusive set of pixels, the different light sources can be lit simultaneously.

In addition, a simple operation by very rapid scanning of all the pixels of the screen suffices to display all the multiplexed images. Because of the Fresnel lens 3, in a given area of the visualization environment 8, only an image displayed by a group of pixels associate with the source will be visible.

In the variant from Figure 6, the spatial multiplexing of the images is obtained with a system comprising an alignment grid 4 (also designated by the term parallax barrier) interposed between the sources A1, A2, B1, B2, C1, C2 and screen 2. This alignment grid 4 only transmits the light generated by each source towards its associated set of pixels. As it happens, the light generated by the source A1 (or A2) is only transmitted towards the pixels 2A shown shaded. The light emitted by the source B1 (or B2) is only transmitted towards the pixels 2B shown shaded. The light emitted by the source C1 (or C2) is only transmitted towards the pixels 2C shown in white.

Grid 4 comprises, for example, windows spaced regularly according to a pattern. This pattern is such that the light coming from a source traverses them and is transmitted to a set of pixels associated with that source. This set of pixels is laid out according to a corresponding pattern.

According to another variant, illustrated in particular by Figure 7, the channeling device is constituted by light deflectors. This variant allows the reduction of energy losses in the area of the grid, since the majority of the light energy emitted by a source gets through in the visualization environment 8. The light energy is in effect directed towards the set of pixels associated by avoiding its absorption.

In the example from Figure 7, the lenses 9, arranged in a network 6, form the light deflectors. The light generated by a source presents the same reference as in Figure 6 is transmitted by the lenses exclusively towards the same set of pixels.

Such lenses 9 can potentially deflect the peripheral light rays. A spacing of the beam traversing the lenses 9 is then noted. This phenomenon can be compensated by lengthening the focal length of the lenses and moving them away from the screen 2. This phenomenon can also be compensated by positioning a second network of lenses close to the screen, and forming an appreciably afocal optical system with the first network 6. This second network has one lens per pixel on the screen. The two networks can be formed on the respective sides of a single plate of transparent material.

The use of other light deflectors such as holographic deflectors can also be considered. Light reflectors can also be used as light deflectors. The light reflectors can be electronically controlled to modify their angle of incidence with a given light source.

In a variant of multiplexing, at least two sources generate respective light having mutual orthogonal polarization. These sources are associated with a screen having two sets of pixels associated respectively to the two sources. Each set filters the light generated with a polarization identical to that of their respective source.

This variant also allows the doubling of the number of multiplexed images displayed by the screen, in displaying two associated overlapping images with respective polarizations. If the screen already includes a polarizing film, this film can be utilized in interposing before one pixel out of two a suitably oriented half-wave plate, which thereby modifies the polarization of the light beams traversing the screen.

Combining the different variants of image multiplexing described can of course be envisaged. Increase the number of different images that it is possible to display in the visualization area can also be increased.

A variant of the system according to the invention is particularly advantageous for restoring different points of view of a single object. This system comprises multiple generators of respective image signals. These signals correspond to the respective images of a single object according to the different points of view. The generators are connected to the signal reception input. A point of view is thereby assigned to an area in an observation environment 8 and the appropriate image is restored in this area.

The image generator can apply multiplexed image signals on a unique system input . The system can also present multiple inputs, each input corresponding to an image signal.

The generators can be constituted by a processor generating said image signals from a modeled object. Each image signal can be calculated as a function of viewing angles of a computerized model in 3 dimensions.

The performance of retouching images taken by cameras filming a real object can also be anticipated. The generators can then be constituted by a processor generating image signals by processing of a single image of the object. To improve the realism of corresponding modified images for the set of view angles, it is of course preferable to arrange a certain number of pictures split over a total observation angle. The image within a view angle close to a picture is then realized from the image from this picture.

As can be observed with Figure 3, the beam coming from a source broadens considerably beyond and on this side of the nominal observation plane in which the point P is located. Out of this nominal plane it is possible that an observer correctly sees the image that is intended for him coming from the center of screen 2, but there is a risk seeing different images at the periphery of screen 2. In addition, the smaller the dimension of the sources, the more limited the depth of observation tolerated in the visualization environment 8.

This problem is resolved by sending the same image towards multiple consecutive areas of the observation environment. Nevertheless, that involves placing the observers at a consistent distance from one another in the observation environment 8. In addition, the different images are recovered proportionally to the distance of the observer from the nominal plane.

Figure 5 illustrates another variant resolving this last problem. This variant includes a set of systems placed side by side and presenting image generators.

Thus, each system presents a screen, a Fresnel lens and multiple light sources associated with an object (identified respectively by the references 21, 31 and 11 for example). As it happens, each screen 21 to 24 that displays a part of the image can be formed from a part of a single screen 2.

As can be observed with figure 5, although the observation position is considered to be out of the observation plane, the image displayed for this position remains correct. The width of the beam for an image displayed in the observation environment 8 is therefore reduced when one moves away from the nominal plane of observation. The overlapping of consecutive images is therefore reduced at a distance from the nominal plane. The depth of observation of this set of systems is also increased. The reduction of the aperture of a display beam for an image also allows the reduction of distortions and the optical aberrations of the display.

As illustrated with figures 3, 5, 6 and 7, the light sources used are preferably adjacent, in particular to increase the compactness of the system. If the light sources are slightly separated, one can position in front of them a diffusing plate in order to fill in the intervals that separate them and in order to cover a solid angle contained in the reproduction space. The diffusing plate is, for example, sufficiently close so that at each point it is only illuminated by one source, or 2 sources along their border. The diffusing plate preferably diffuses the light with an angle such that the beam coming from a source is only superimposed on the fringe of the beam coming from an adjacent source. This angle is in this case relatively high.

Sources presenting a uniform illumination for the area to which they are assigned are advantageously utilized in order to not have differences in contrast in the displayed image. The luminosity of a source can also be made uniform by interposing a diffuser away from the source, on the light path between this source and the screen 2. This diffuser can then be expected to weakly deflect the light, for example by using slight, tight undulations of its surface. The deflection must then be limited in order to limit the superimposition at their edge of beams coming from adjacent sources.

The set of sources can be expected to cover a solid angle without allowing unlit intervals.

Adequate sources will be utilized for being switched sufficiently rapidly when the variant utilizing temporal multiplexing is used. Adequate sources can be used such as luminescent diodes or a light emitting screen for which a group of pixels is utilized to form each source.

The sources can also be formed from a single spread out light source and modulators positioned on the light path between the source and screen 2. The modulators allow the selective occlusion of undesirable areas when the variant utilizing temporal multiplexing is used. Using mirrors whose orientation is controlled electronically can also be anticipated.

Such mirrors then selectively direct the light from the source in different directions towards the screen, when the variant using temporal multiplexing is used. The single extended light source involves an increased consumption of energy.

When the images are only horizontally multiplexed, sources in the shape of thin vertical bands can be used.

Light sources that are identical or of the same size can preferably be provided, to create respective areas in the visualization environment of identical sizes. The sources are, for example, distributed in a plane parallel to the plane of the screen.

According to a variant illustrated in Figures 6 and 7, multiple overlapping images are displayed simultaneously on screen 6, each one of them only being illuminated by certain sources. In this case, the sources for which the reference presents the same letter of the alphabet are associated to the same image. At each instant therefore, multiple images are displayed, where each one can be associated to a sub-set of sources. Other modes of multiplexing such as temporal multiplexing can be applied to each of these sub-sets of sources and to the sub-sets of associated pixels. The number of different images that can be displayed simultaneously in the distinct areas can also be increased.

Preferably, it can be anticipated that the transmissibility of the screen's pixels can vary continuously between two limits of transmissibility. The display intensity of each pixel can also be modulated under good conditions.

Preferably a screen presenting pixels with variable transmissibility but not deflecting the incident light issued by the sources can also be used. Some liquid crystal displays have such properties.

The Fresnel lens 3 can of course be positioned on one side or the other of screen 2. The Fresnel lens 3 is positioned near screen 2, at an adequate distance for focusing the light from a source towards an area of the respective visualization environment. A person skilled in the art could readily determine such a distance from their general knowledge.

In the case where a horizontal multiplexing of the images is done, it is preferable that the lens makes a vertical concentration of the beam traversing it, in order to avoid losses of light. Vertical lenses in a nearly cylindrical shape can also be used.

By displaying images of the object on the screen according to horizontally varying points of view, a binocular vision can be obtained because the eyes of the viewer are generally in the same horizontal plane. According to the spatial multiplexing embodiment, the pixels from the same vertical section of the screen would display pixels of the same image.